THE NEW DDESB BLAST EFFECTS COMPUTER

prepared by

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ABSTRACT

In 1978, the Department of Defense Explosives Safety Board (DDESB) released a circular slide rule called the "Blast Effects Computer (BEC)." This slide rule was designed to solve problems and provide data related to the expected damage to various possible targets due to blast effects resulting from an explosion of ammunition or explosives stored above ground or in earth-covered magazines. In the 20 years that have elapsed since the slide rule was designed, the state of the art in predicting both blast effects and damage has progressed significantly. However, the need for a prediction tool has not disappeared in the intervening years; if anything, this need has increased. As a result, the DDESB has prepared an update to the circular slide rule. This update is in the form of an EXCEL spreadsheet template that will run on any computer upon which EXCEL Version 5.0 (or later) is installed. Version 1.0 of the new blast effects computer (BECV1) was a simple computerization of the circular slide rule with an update to the Kingery airblast pressure-distance model and other minor corrections to the algorithms. This version was released in November 1997. Version 2.0 is now available. Incorporated into this version are updated airblast information for earth-covered magazines and hardened aircraft shelters. Also included are updated airblast algorithms for MK 82, MK 83, MK 84 and M117 bombs, as well as M107 155-mm projectiles. This paper describes BECV2, discusses some of the new algorithms that are used, and demonstrates the computer's use through illustrative examples.

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BACKGROUND

The Department of Defense Explosives Safety Board (DDESB) has had an active role in producing various types of explosion effects computation aids[1]. In 1978, these culminated in the release of a circular slide rule called the "Blast Effects Computer (BEC)[2]." This slide rule was designed to solve problems and provide data related to the expected damage to various potential targets due to blast effects resulting from an explosion of ammunition or explosives stored above ground or in earth-covered magazines.

The following outline provides a brief description of the circular slide rule and its capabilities:

SIDE 1--BOMBS AND PROJECTILES

Input:

- open revetments/earth-covered magazine
- number and type of weapon
- MK 82/M117/M437A2 (175 mm shell)/M107 (155 mm shell)
- or total NEW of weapons

Output:

- effective yield (pounds of TNT)
  - NEW x FANO Factor x TNT equivalence x 1.2 directional factor
- pressure-distance
- positive phase duration-distance
- dynamic overpressure impulse-distance
- Intraline distance
  - barricaded/unbarricaded
- Inhabited building distance
- Public highway and passenger railroad distance
- frame house damage
  - threshold/50% damage/total/glass breakage
- parked aircraft damage
  - threshold/not flyable/total
- truck damage (crushing)
  - threshold/total
- truck damage (overturning)
  - threshold/total
- personnel injuries (tertiary effects)
  - body
    - 99%/50%/threshold
  - head
    - 99%/50%/threshold
- personnel injuries (primary effects)
  - lung damage
    - 99%/90%/50%/10%/threshold
  - ear damage
    - 90%/50%/10%/threshold

SIDE 2--BULK EXPLOSIVES AND LIGHT CASED MUNITIONS

Input:

- open revetments/earth-covered magazine
- type of explosive
  - H-6/Tritonal/Comp B/TNT
- total NEW

Output:

- effective yield (pounds of TNT)
  - NEW x cover factor x TNT equivalence x 1.2 directional factor
- cube root multiples of effective TNT yield
- pressure-distance
- positive phase duration-distance
- dynamic overpressure impulse-distance
- Intraline distance
  - barricaded/unbarricaded
- Inhabited building distance
- Public highway and passenger railroad distance
- frame house damage
  - threshold/50% damage/total/glass breakage
- parked aircraft damage
  - threshold/not flyable/total
- truck damage (crushing)
  - threshold/total
- truck damage (overturning)
  - threshold/total
- personnel injuries (tertiary effects)
  - body
    - 99%/50%/threshold
  - head
    - 99%/50%/threshold
- personnel injuries (primary effects)
  - lung damage
    - 99%/90%/50%/10%/threshold
  - ear damage
    - 90%/50%/10%/threshold

The algorithms that were developed for the original BEC are described in detail in Reference 1. Last year, these algorithms were implemented into an EXCEL spreadsheet template. This version, referred to as BECV1, was released in November 1997 and was reported at PARARI 97, the Australian safety seminar[3].

The organization and use of this original version of the EXCEL template was described in detail at that seminar and will not be repeated here. This paper will describe the changes that have been implemented into Version 2.0.

VERSION 2.0 GENERAL INFORMATION

Version 2.0 incorporates several significant improvements into the models. In version 2.0, in addition to open stacks of ammunition, the user can choose earth-covered magazines (front, side, and rear directions) and hardened aircraft shelters (front, side, and rear). In version 1.0, the airblast estimates for all cased weapons were very approximate—simply being based on a Kingery hemispherical TNT curves with a FANO-type correction for the case effect. In the latest version, the airblast estimates for cased weapons are tied to experimental results.

The choice of explosive fills has also been expanded in the new version. The list of potential explosives has been expanded from H-6, Tritonal, Composition B, and TNT to H-6, Tritonal, Composition B, TNT, Composition A3, Composition C4, Explosive D, HBX-1, HBX-3, Minol II, and ANFO.

The ***Back Calculation*** option provided in Version 1.0 has been removed and replaced by a built-in EXCEL tool, the ***Goal Seek*** option under the **Tools Menu**.

Version 2.0 is now available in both English and SI units. The English version is BECVE2; The SI version is BECVM2.

AIRBLAST PARAMETER ALGORITHMS

The combination of **Open Storage** under ***Select Type of Magazin***e and **Bulk/Light Cased** under ***Select Type of Weapon*** leads to the use of the simplified Kingery equations[4] to predict the airblast. The airblast predictions for all other situations are based on these equations as modified by experimental results. These modifications are in the form of algorithms that relate the yield of the weapon at a particular range to an equivalent hemispherical TNT weight. This TNT weight and the hemispherical airblast equations are then used to make the estimates of the airblast parameters.

Built into the BEC are functions which express the yield of each combination of Type of Storage, Type of Weapon, and Type of Explosive in terms of an equivalent hemispherical TNT weight. This equivalent TNT weight is the weight that is used to actually compute the airblast. For example, the actual Net Explosive Weight (NEW) of a MK 82 bomb is 192 pounds of Tritonal. The Equivalent Hemispherical TNT weight varies between 235 pounds and 374 pounds. The effect of this variable yield is to allow the BEC to accurately reproduce the airblast parameters that have been recorded at various distances for the various weapons and storage conditions.

The Earth-Covered Magazine (ECM) airblast is based on a refinement of the data presented in Reference 5. Specifically, the Reference 5 data have been extended to cover much smaller scaled distances. The empirical fits to these data are presented in Table 1.

TABLE 1. AIRBLAST COEFFICIENTS—EARTH-COVERED MAGAZINES

FUNCTION	RANGE	DIRECTION	A	B	C
PRESSURE	Z<=19	Front	3183.8	-2.7054	0.1118
(P)	Z>19		799.43	-2.1850	0.09419
	Z<=14	Side	110.37	-0.9700	-0.08852
	Z>14		70.711	-0.70889	-0.12311
	Z<=14	Rear	144.76	-1.4700	0.01605
	Z>14		89.157	-1.0867	-0.05778
IMPULSE	Z<=15	Front	64.386	-0.6274	-0.1276
($I/W^{1/3}$)	Z>15		54.038	-0.80719	-0.0385
	Z<=15	Side	11.500	0.1772	-0.2067
	Z>15		18.433	-0.19965	-0.13156
	Z<=15	Rear	10.339	-0.07546	-0.1473
	Z>15		10.291	-0.12798	-0.12788

FORM: P (or $I/W^{1/3}$) = $A*Z^{(B+C*\ln(Z))}$

Z = Range/Weight $^{1/3}$ (ft/lb$^{1/3}$)

P in psi

W in pounds

I in psi-ms

The Hardened Aircraft Shelter (HAS) airblast is based on a new compilation of all of the available data. These curve fits are presented in Table 2. Similar data for positive impulse does not currently exist.

TABLE 2. AIRBLAST COEFFICIENTS—HARDENED AIRCRAFT SHELTER

FUNCTION	DIRECTION	A	B	C	D
PRESSURE	Front	1831.1	-5.9194	1.9455	-0.2439
(P)	Side	15.7179	0.0963	-0.25163	0.01076
	Rear	24.2617	-1.1910	0.36832	-0.09103

FORM: P = $A*Z^{[B+C*\ln(Z)+D*(\ln(Z))^2]}$

Z = Range/Weight $^{1/3}$ (ft/lb$^{1/3}$), P in psi, W in pounds

Analysis of the airblast produced by earth-covered magazines has indicated that it is independent of both the type of ammunition and the type of explosive. Rather, it is dependent only upon the total explosive weight. This fact has been implemented into the BEC. The airblast predictions do not change as the type of weapon and/or the type of explosive is changed. The data base for hardened aircraft shelters is much more limited than for earth-covered magazines. However, for purposes of implementation into the BEC, it has been assumed that a HAS will behave in a similar manner to an ECM; therefore, the airblast depends only on the total explosive weight and is independent of the type of ammunition and type of explosive.

VERSION 2.0 CHANGES

There is an English version and a Metric (SI) version available. The user must choose which system of units in which to operate. The basic operation of the BEC is the same in both units. For convenience only, the remainder of the discussion is presented in English units.

In this latest version, there are seven options possible under the heading "***Select Type of Magazin***e." These are: open storage, ECM-Front, ECM-Side, ECM-Rear, HAS-Front, HAS-Side, and HAS-Rear.

There have been several additions and deletions to the "***Select Type of Weapon***" section. When this section is opened, the following options are presented: MK 82 (500 lb Bomb), MK 83 (1000 lb Bomb), MK 84 (2000 lb Bomb), M117 (750 lb Bomb), M107 (155 mm shell), and Bulk/Light Cased. For all of the bombs, the default explosive is TRITONAL. For the M107 projectile, the default explosive is Composition B and for Bulk/Light Cased items the default explosive is TNT. Even though a default explosive is always chosen by the computer, this choice can be over-ridden and any of the explosives listed under the heading "***Select Type of Explosive***" can be chosen at any time. The equivalent weights that are assumed for each of the explosives that are provided in this version of the BEC are shown in Table 3. An energetic material will have several equivalent weights—depending on the airblast parameter upon which the equivalence is determined. Usually, equivalences are reported for peak pressure and positive impulse. Moreover, the equivalence will vary with the range at which it is computed. The values shown in Table 3 are based on peak pressure and are average values. Equivalent weights based on impulse are generally less than those based on peak pressure. Therefore, by using peak pressure values, a degree of conservatism is built into the impulse estimates.

TABLE 3. AVERAGE EQUIVALENT WEIGHTS RELATIVE TO TNT

EXPLOSIVE TYPE	AVERAGE EQUIVALENT WEIGHT (relative to TNT)
TNT	1.00
H-6	1.35
Tritonal	1.07
Composition B	1.11
Composition A3	1.07
Composition C4	1.30
Explosive D	0.92
HBX-1	1.17
HBX-3	1.14
Minol II	1.20
ANFO	0.83

SELECTED AIRBLAST COMPARISONS

Let us consider several examples and compare the airblast predicted by the BEC with the values predicted by empirical curve fits. Consider four situations: (1) Single MK 82 bomb (Tritonal filled) compared with the standard empirical equations, (2) 10 MK 84 bombs (Tritonal filled) compared with the standard empirical equations, (3) 100,000 pounds (NEW) of TNT inside an earth-covered magazine) compared with the empirical equations given in Table 1, and (4) 10,000 pounds NEW inside a hardened aircraft shelter compared with the equations given in Table 2.

MK 82 Bomb. Table 4A presents the comparison for a single Tritonal-filled MK 82 bomb. Shown are BEC predictions for both peak pressure and positive impulse as well as empirically-predicted values. The average difference between the empirical curve fits and the BEC predictions are less than -1% for peak pressure and -15% for positive impulse.

MK 84 Bomb. Table 4B presents the comparison for a 10 Tritonal-filled MK 84 bombs. Shown are BEC predictions for both peak pressure and positive impulse as well as empirically-predicted values. The average difference between the empirical curve fits and the BEC predictions are less than 2% for peak pressure and -10% for positive impulse.

TABLE 4A. SINGLE MK 82 BOMB (TRITONAL FILLED)

RANGE	PRESSURE		IMPULSE	
	Empirical	BECV	Empirical	BECV
(feet)	(psi)	(psi)	(psi-ms)	(psi-ms)
15	231.6	211.9	233.91	164.02
20	123.3	123.2	174.39	149.35
30	52.72	56.17	115.28	116.23
40	29.63	31.00	85.95	93.63
50	19.25	19.61	68.44	78.07
60	13.67	13.59	56.82	68.00
70	10.30	10.08	48.54	59.93
80	8.11	7.86	42.36	53.38
100	5.49	5.30	33.73	43.47
150	2.80	2.77	22.30	29.01
200	1.79	1.82	16.62	21.37
300	0.98	1.04	10.99	13.63
400	0.66	0.71	8.19	9.81
500	0.49	0.50	6.52	7.59
600	0.39	0.39	5.42	6.28
AVERAGE DIFFERENCE (%)		-0.67		-14.16

TABLE 4B. TEN MK 84 BOMBS (TRITONAL FILLED)

RANGE	PRESSURE		IMPULSE	
	Empirical	BECV	Empirical	BECV
(feet)	(psi)	(psi)	(psi-ms)	(psi-ms)
50	288.8	263.8	944.32	550.81
60	192.3	180.8	783.96	594.59
70	137.32	142.73	669.81	585.87
100	64.58	70.66	465.40	470.89
150	28.56	29.91	307.66	340.62
200	16.45	16.39	229.37	267.63
300	7.85	7.43	151.63	188.62
400	4.77	4.48	113.04	142.91
500	3.29	3.13	90.02	113.70
600	2.46	2.37	74.73	93.56
700	1.93	1.89	63.85	79.15
1000	1.13	1.15	44.36	52.95
1500	0.65	0.65	29.33	32.93
2000	0.44	0.43	21.87	23.70
AVERAGE DIFFERENCE (%)		1.46		-8.32

Earth-Covered Magazine. Table 5 compares the airblast predicted by the BEC with that computed using the equations shown in Table 1. The average differences in peak pressures vary from –5.6% to the front to 2.8% to the rear. The positive impulse differences vary from –17.3% to the front, -4.2% to the side, and –1.6% to the rear.

TABLE 5. EARTH-COVERED MAGAZINE (100,000 LBS NEW OF TNT)

DIRECTION	RANGE	PRESSURE		IMPULSE	
	(feet)	Empirical (psi)	BECV (psi)	Empirical (psi-ms)	BECV (psi-ms)
FRONT	100	426.3	396.6	1712.69	1157.33
	150	155.4	165.6	1201.15	1399.43
	200	77.68	83.29	910.38	1082.42
	300	30.16	30.30	594.28	688.72
	400	15.76	15.19	428.08	500.67
	500	9.65	9.20	327.11	391.15
	600	6.52	6.29	260.10	315.45
	700	4.70	4.64	212.86	260.75
	800	3.56	3.62	178.06	219.81
	1000	2.26	2.45	130.80	163.43
	1500	1.01	1.27	72.28	92.60
	2000	0.59	0.81	46.26	60.75
	AVERAGE DIFFERENCE (%)		**-5.56**		**-17.25**
SIDE	100	49.76	51.96	541.44	362.59
	150	31.32	31.73	494.45	358.12
	200	22.16	22.07	444.88	345.07
	300	13.27	13.03	361.71	327.10
	400	9.06	8.88	299.70	302.18
	500	6.67	6.58	252.99	276.11
	600	5.16	5.13	216.94	251.00
	700	4.14	4.15	188.47	227.65
	800	3.40	3.44	165.52	206.31
	1000	2.44	2.51	131.07	169.54
	1500	1.30	1.38	81.37	105.49
	2000	0.82	0.86	55.67	67.50
	3000	0.42	0.37	30.77	29.40
	AVERAGE DIFFERENCE (%)		**-0.39**		**-4.17**
REAR	100	47.29	49.1	415.25	345.26
	150	26.39	26.5	358.66	300.96
	200	17.50	17.39	313.90	281.55
	300	9.85	9.69	249.58	246.96
	400	6.58	6.48	205.97	217.48
	500	4.81	4.77	174.51	192.31
	600	3.74	3.72	150.75	170.73
	700	3.02	3.02	132.19	152.14
	800	2.51	2.52	117.31	136.05
	1000	1.85	1.85	94.96	109.81
	1500	1.06	1.03	62.30	67.18
	2000	0.72	0.65	44.86	43.09
	3000	0.42	0.32	27.09	23.10
	AVERAGE DIFFERENCE (%)		**2.83**		**-1.58**

Hardened Aircraft Shelter. Table 6 compares the airblast predicted by the BEC with that computed using the equations shown in Table 2. The average differences in peak pressures vary from 3.6% to the front to 1.3% to the rear.

TABLE 6. HARDENED AIRCRAFT SHELTER (10,000 LBS NEW)

DIRECTION	RANGE (feet)	PRESSURE Empirical (psi)	PRESSURE BECV (psi)	IMPULSE Empirical* (psi-ms)	IMPULSE BECV (psi-ms)
FRONT	70	17.11	12.22		71.98
	80	12.74	10.47		71.03
	90	10.11	9.27		70.97
	100	8.40	8.01		68.03
	150	4.81	4.85		58.83
	200	3.61	3.86		59.49
	300	2.62	2.78		58.38
	400	2.10	2.06		51.39
	500	1.74	1.62		44.97
	700	1.21	1.18		38.36
	800	1.02	1.04		36.34
	1000	0.71	0.80		29.86
	AVERAGE DIFFERENCE (%)		**3.57**		
SIDE	60	13.48	14.01		69.88
	70	12.63	12.77		74.93
	80	11.85	11.74		79.24
	90	11.13	10.89		82.97
	100	10.47	10.16		86.23
	150	7.95	7.65		97.27
	200	6.29	6.12		102.10
	300	4.30	4.27		101.08
	400	3.18	3.19		93.31
	500	2.47	2.48		83.50
	700	1.64	1.65		64.83
	800	1.38	1.39		57.02
	1000	1.03	1.03		44.59
	1500	0.58	0.56		26.51
	AVERAGE DIFFERENCE (%)		**0.64**		
REAR	60	9.56	9.11		46.48
	70	8.57	8.46		50.34
	80	7.81	7.74		52.52
	90	7.19	7.14		54.28
	100	6.68	6.63		55.68
	150	4.95	4.85		58.81
	200	3.88	3.79		58.15
	300	2.57	2.54		51.76
	400	1.79	1.82		42.69
	500	1.29	1.33		33.30
	700	0.72	0.72		17.81
	800	0.55	0.51		12.34
	AVERAGE DIFFERENCE (%)		**1.31**		

*Data not available

BACK CALCULATIONS

Explosion effects depend upon the inter-relationship of three sets of data: (1) the net explosive weight (NEW), (2) the range, and (3) the type of explosion effect (time of arrival, positive phase duration, etc.). If two of these are known, then the third can be computed. When the NEW and range are known, the BEC computes the effect. It is often useful to reverse this process; i.e., to enter the range and the effect and compute the NEW or to enter the effect and the NEW and compute the range. This reverse process is referred to as back calculation.

When it is planned to use this feature, either the range or the NEW must be entered at the top of the spreadsheet. An arbitrary value for the other input variable must also be used--any number greater than zero. Make the appropriate selections from the other inputs: ***Select Type of Magazine***, ***Select Type of Weapon***, and ***Select Type of Explosive***. When the other inputs are complete, select the ***Goal Seek*** Function under the EXCEL **TOOLS** menu. When this option is selected, the following dialog box is displayed:

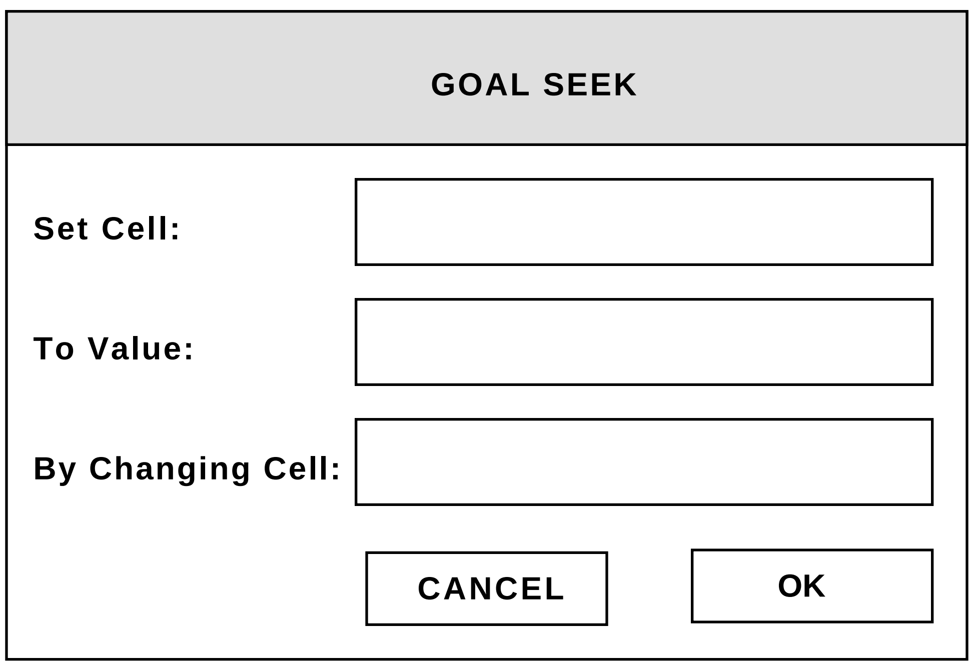

FIGURE 1. DIALOG BOX FOR BACK CALCULATIONS

Enter the Cell Reference of the cell you wish to compute into the ***Set Cell:*** box. Enter the value you wish the cell to obtain in the ***To Value:*** box. Enter the Cell Reference of the Cell you wish to change into the ***By Changing Cell:*** box. The Cell References for each of the parameters of interest are given in Table 7.

TABLE 7. CELL REFERENCES

FUNCTION	CELL REFERENCE
Total NEW or Number of Weapons	G5
Range	H5
Time of Arrival at Range	B20
Overpressure at Range	B22
Reflected Pressure at Range	B24
Positive Phase Duration at Range	B26
Positive Phase Impulse at Range	B29
Reflected Impulse at Range	B32
Shock Front Velocity at Range	B35
Dynamic Overpressure Impulse at Range	B38
Intraline Distance--Barricaded	C41
Intraline Distance--Unbarricaded	B41
Inhabited Building Distance	B43
Public Traffic Route Distance	B45

When you are satisfied with the inputs in the ***Goal Seek*** dialog box, click **OK**. When the Goal Seek process is complete, click **OK** in the new box. The spreadsheet will be displaying all of the selected values. Example 2 (below) illustrates the use of the **Goal Seek** function.

EXAMPLES

The following examples are intended to illustrate some of the features of BECV2.

Example 1.

Statement of problem: A total of 250,000 lbs net explosive weight (NEW) of MK 83 bombs (Tritonal filled) are stacked in an open storage. What are the airblast effects at 2000 ft? At what distance from the stack will undesirable effects result in the event of an accidental explosion?

Inputs:

Type of Magazine	***Open Storage***
Type of Weapon	***MK 83 Bombs***
Type of Explosive	***Tritonal***
Number of Weapons or Total NEW	***Total NEW***
Total NEW (lbs)	***250,000***
Range (ft)	***2,000***

Outputs:

The output (shown below as Figure 2) indicates the effective yield of the 250,000 lbs (NEW) of Tritonal in MK 83 bombs is 267,500 lbs. The equivalent hemispherical weight is 430,748 pounds. The **Explosive Parameters** section of the output gives the airblast effects at 2,000 ft (for example, the over-pressure is 2.02 psi at 2,000 ft). In the **Other Information** section of the output - unbarricaded (K18) and barricaded (K9) intraline distances (ILDs) [1359 ft and 680 ft, respectively], inhabited building distance (IBD) for blast effects only [3776 ft], and public traffic route (PTR) distance for blast effects only [2266 ft] are given. The remainder of the output section supplies the damage effects (undesirable effects) resulting from such a detonation. These include: 50% glass breakage at 1509.8 ft (using an overpressure criterion of 3 psi), Not flyable parked aircraft damage at 2014.7 ft (using an overpressure criterion of 2 psi), Total truck damage from crushing at 440.3 ft (using an overpressure criterion of 30 psi), Threshold for personnel injury (tertiary) for the head at 969.0 ft (using an impulse criterion of 54 psi-ms), and 50% probability of personnel injury (primary) ear damage at 949.4 ft (using an overpressure criterion 6.3 psi).

FIGURE 2A. EXAMPLE 1—INPUTS AND AIRBLAST PARAMETERS

INPUT SECTION:

Select Type of Magazine	Select Type of Weapon	Select Type of Explosive	Select Number of Weapons or Total NEW	Enter Total NEW (lbs)	Enter Range (ft)
Open Storage	MK 83 (1000 lb Bomb)	Tritonal	Total NEW	250,000.0	2,000.0

OUTPUT SECTION:

EXPLOSIVE PARAMETERS

Total NEW (lb)	250,000.0
NEW per weapon (lb)	445
TNT Equivalence	1.07
Equivalent Hemispherical Weight	430,747.6
Effective Yield	267,500.0

(N.B.: Both Weight and Yield are in lbs of TNT)

AIRBLAST PARAMETERS

Range (feet)	2,000.0
Time of Arrival at Range (msec)	1335.59
Over-Pressure at Range (psi)	2.02
Reflected Press. at Range (psi)	4.26
Positive Phase Duration at Range (msec)	282.7
Positive Phase Impulse at Range (psi-msec)	249.1
Reflected Impulse at Range (psi-msec)	474.1
Shock Front Velocity at Range (kft/sec)	1.179

FIGURE 2B. EXAMPLE 1—INPUTS AND OTHER INFORMATION

INPUT SECTION:

Select Type of Magazine	Select Type of Weapon	Select Type of Explosive	Select Number of Weapons or Total NEW	Enter Total NEW (lbs)	Enter Range (ft)
Open Storage	MK 83 (1000 lb Bomb)	Tritonal	Total NEW	250,000.0	2,000.0

OUTPUT SECTION:

EXPLOSIVE PARAMETERS

Total NEW (lb)	250,000.0
NEW per weapon (lb)	445
TNT Equivalence	1.07
Equivalent Hemispherical Weight	430,747.6
Effective Yield	267,500.0

(N.B.: Both Weight and Yield are in lbs of TNT)

OTHER INFORMATION

Dynamic Overpressure Impulse at Range (psi-msec)	10.1				
	Unbarricaded	Barricaded			
Intraline Distance (ft)	1359	680			
Inhabited Building Distance (ft)	3776	(Blast only)			
Public Traffic Route Distance (ft)	2266	(Blast only)			
	Glass Breakage	Threshold	50%	Total	
Frame House Damage (ft)	9562.2	3757.9	1509.8	1087.8	
criteria (psi)	(0.25)	(0.9)	(3)	(5)	
	Threshold	Not Flyable	Total		
Parked Aircraft Damage (ft)	3454.9	2014.7	1249.3		
criteria (psi)	(1)	(2)	(4)		
Truck Damage	Threshold	Total			
Crushing (ft)	976.5	440.3			
criteria (psi)	(6)	(30)			
Overturning (ft)	777.5	462.7			
criteria (psi-msec)	(90)	(300)			
Personnel Injuries (Tertiary)	Threshold	50%	99%		
Body (ft)	802.6	717.0	673.9		
criteria (psi-ms)	(83.6)	(108.6)	(125.4)		
Head (ft)	969.0	841.0	756.1		
criteria (psi-ms)	(54)	(75)	(96)		
Personnel Injuries (Primary)	Threshold	10%	50%	90%	99%
Lung Damage (ft)	612.5	560.5	519.9	470.4	444.0
criteria (psi)	(14.5)	(17.5)	(20.5)	(25.5)	(29)
Ear Damage (ft)	1764.2	1583.0	949.4	666.7	n/a
criteria (psi)	(2.4)	(2.8)	(6.3)	(12.2)	n/a

Example 2.

Statement of problem: The boundary of an installation (an area that requires Inhabited Building Distance (IBD) level of protection) is 4,000 feet from an aboveground magazine. How many H-6 loaded MK 82 bombs may be stored in the magazine and still achieve equivalent IBD level of protection? What is the equivalent hemispherical TNT weight of the bombs at that distance? What are the other airblast parameters that may be of interest? (Note: Equivalent IBD level of protection corresponds to a pressure level of 0.9 psi for Net Explosive Weights greater than 250,000 pounds).

The **BACK CALCULATION** or **GOAL SEEK** option should be used to solve this problem.

Inputs:

Type of Magazine	***Open Storage***
Type of Weapon	***MK 82 Bombs***
Type of Explosive	***H-6***
Number of Weapons or Total NEW	***Number of Weapons***
Number of Weapons	***10 (arbitrary, such that the Overpressure at Range Cell indicates a number)***
Range (ft)	***4,000***

Select ***Goal Seek*** function under the **TOOLS** menu. When the Goal Seek dialog box appears, enter B22 into ***Set Cell*** box. Enter the value 0.9 into the ***To Value*** box. Enter G5 into the ***By Changing Cell*** box. (Note: This tells the computer that you wish to vary the number of weapons (Cell G5) until the Overpressure at Range (Cell B22) achieves a value of 0.9 psi). Press ***OK***. When the Goal Seek function is completed, press **OK** in the dialog box that appears.

Outputs:

The output (shown below as Figure 3.) indicates that 1,566.2 weapons can be stored and still achieve equivalent IBD blast protection (0.9 psi) at a range of 4,000 feet. This number of weapons is equivalent to 519,235.9 pounds of hemispherical TNT at 4,000 feet. It should be noted, however, that for compliance with the requirements of DoD 6055.9-STD, the actual NEW rather than an effective yield or equivalent hemispherical yield must be used for establishing quantity-distances such as IBD, PTR, and ILD.

FIGURE 3A. EXAMPLE 2—INPUTS AND AIRBLAST PARAMETERS

INPUT SECTION:

Select Type of Magazine	Select Type of Weapon	Select Type of Explosive	Select Number of Weapons or Total NEW	Enter Number of Weapons	Enter Range (ft)
Open Storage	MK82 (500 lb Bomb)	H-6	Number of Weapons	1,566.2	4,000.0

OUTPUT SECTION:

EXPLOSIVE PARAMETERS

Total NEW (lb)	300,716.1
NEW per weapon (lb)	192
TNT Equivalence	1.35
Equivalent Hemispherical Weight	519,235.9
Effective Yield	405,966.8

(N.B.: Both Weight and Yield are in lbs of TNT)

AIRBLAST PARAMETERS

Range (feet)	4,000.0
Time of Arrival at Range (msec)	3028.8
Over-Pressure at Range (psi)	0.9
Reflected Press. at Range (psi)	1.8
Positive Phase Duration at Range (msec)	366.0
Positive Phase Impulse at Range (psi-msec)	144.1
Reflected Impulse at Range (psi-msec)	260.4
Shock Front Velocity at Range (kft/sec)	1.145

FIGURE 3B. EXAMPLE 2—INPUTS AND OTHER INFORMATION

INPUT SECTION:

Select Type of Magazine	Select Type of Weapon	Select Type of Explosive	Select Number of Weapons or Total NEW	Enter Number of Weapons	Enter Range (ft)
Open Storage	MK82 (500 lb Bomb)	H-6	Number of Weapons	1,566.2	4,000.0

OUTPUT SECTION:

EXPLOSIVE PARAMETERS

Total NEW (lb)	300,716.1
NEW per weapon (lb)	192
TNT Equivalence	1.35
Equivalent Hemispherical Weight	519,235.9
Effective Yield	405,966.8

(N.B.: Both Weight and Yield are in lbs of TNT)

OTHER INFORMATION

Dynamic Overpressure Impulse at Range (psi-msec)	2.5				
	Unbarricaded	Barricaded			
Intraline Distance (ft)	1447	723			
Inhabited Building Distance (ft)	4019	(Blast only)			
Public Highway and Passenger Road dist. (ft)	2411	(Blast only)			
	Glass Breakage	Threshold	50%	Total	
Frame House Damage (ft)	10176.7	3999.4	1606.8	1157.7	
criteria (psi)	(0.25)	(0.9)	(3)	(5)	
	Threshold	Not Flyable	Total		
Parked Aircraft Damage (ft)	3676.9	2144.2	1329.5		
criteria (psi)	(1)	(2)	(4)		
Truck Damage	Threshold	Total			
Crushing (ft)	1039.2	468.6			
criteria (psi)	(6)	(30)			
Overturning (ft)	850.0	505.9			
criteria (psi-msec)	(90)	(300)			
Personnel Injuries (Tertiary)	Threshold	50%	99%		
Body (ft)	877.4	783.8	736.7		
criteria (psi-ms)	(83.6)	(108.6)	(125.4)		
Head (ft)	1059.3	919.4	826.6		
criteria (psi-ms)	(54)	(75)	(96)		
Personnel Injuries (Primary)	Threshold	10%	50%	90%	99%
Lung Damage (ft)	651.8	596.5	553.3	500.6	472.5
criteria (psi)	(14.5)	(17.5)	(20.5)	(25.5)	(29)
Ear Damage (ft)	1877.6	1684.7	1010.4	709.5	n/a
criteria (psi)	(2.4)	(2.8)	(6.3)	(12.2)	n/a

HARDWARE/SOFTWARE REQUIREMENTS

The new BEC is written as a Microsoft EXCEL Spreadsheet template. In order to use BECV2, EXCEL (Version 5.0 or higher) must already be installed on your computer. Simply copy BECV2 to your hard drive. To use the program, either double click on the BECV2 filename or launch EXCEL and then use the ***OPEN*** command located in the FILE menu. Because it is written as an EXCEL template, BECV2 will run on any machine that can run EXCEL. Currently, it has been tested on both Macintosh and WINTEL machines. The MAC was using EXCEL Version 5.0 or EXCEL 98 (part of the Microsoft Office 97 suite). The WINTEL machines (using Windows 95) were running EXCEL 97 (part of the Microsoft Office 97 suite) and EXCEL 5.0 (part of Office 95).

When you open a template, EXCEL opens a copy of the template for you to use. Changes you make affect only the copy; the original template is preserved. The copy of the template is a new, unsaved document with a temporary name based on the template name. For example, when you open the Blast Effects Computer template named BECV2.XLT, Microsoft EXCEL gives the copy the temporary name BECV21. When you save or close the copy, the Save As dialog box appears. You can type a new name for the document or accept the temporary name suggested by EXCEL.

When you open the template with EXCEL 97 or EXCEL 98, you will be presented with a dialog box that indicates, ***" The workbook you are opening contains macros …"***. Click on the "**Enable Macros**" button to proceed. You may then be presented with a dialog box concerning Visual Basic. Click **OK** to proceed and open BECV.

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